final report

EFFECTS OF MASS FIRES ON FALLOUT DEPOSITION

By: William B. Lane and Hong Lee

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LANE, William B.
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13. ABSTRACT

This report summarizes the importance of evaluating the effects of mass fires on fallout deposition and the state of knowledge on this interaction. An experiment was designed to measure the results of a mass fire interacting on depositing and deposited simulated fallout.

The results obtained from a limited participation in an Operation Flambeau fire are also reported. The results from the crude experiments indicated the existence of significant mass fire-deposited fallout interaction and substantiated the feasibility of conducting the designed experiment.

14. KEY WORDS	LINK A		LINK B		LINK C	
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INTRODUCTION

Background

Little or no experimental data on the interactions between mass fires and fallout particles are available, and no studies have been made of the influence of mass fires on the deposition patterns of radioactive fallout.

Large scale fires cause high velocity air movements. Surface wind velocities of 30 to 40 miles per hour were reported at Hiroshima,[1] and estimated velocities at Hamburg were up to 170 miles per hour.[2] From these figures, it may be inferred that the vertical convection column velocities would be great enough to exceed the terminal velocity of falling particles and thus would alter their path of fall and the location of their deposition. Horizontal in-drafts and high velocity swirls may pick up and redistribute fallout particles deposited before the fire.

A recent study investigated the casualties that might result if people were forced by fire to leave shelters and proceed to or through areas that are contaminated by fallout. It was estimated that there would be three times more fatalities from radiation exposure than from blast effects.[3] The estimate was based on the assumption that fallout patterns would not be altered by the induced convective effects of fire. If the convection column prevented fallout from arriving or if fallout were removed by surface winds, the estimated radiation overexposures and the conclusion of the referenced study could be greatly altered.

To date, the most significant work relating to interactions between fire and fallout deposition was performed by Broido and McMasters.[4] Experiments were conducted in a 6 by 6 foot low-velocity wind tunnel. Mineral particles were injected into the air stream upwind from a gas fire, and the effect of the fire updrafts on particle deposition was measured. These experiments could not reproduce the in-drafts or fire swirls that occur in mass fires; and the scaling of these experimental data to mass fires would be difficult, if not impossible. One of the principal conclusions of Broido's study was that the updrafts from fire could alter particle deposition patterns. However, further experiments at large field tests of open fires would be required to evaluate the degree of alteration by the combined effects of in-drafts, fire swirls, and updrafts.

The behavior of large fires is currently being studied by the U.S. Forest Service, under sponsorship of the Defense Atomic Support Agency and the Office of Civil Defense. This study includes experimental burns (Operation Flambeau) of square piles of wood about 45 feet on a side and about 10 feet high in rectangular arrays to represent residential areas. A 50-acre burn of 380 piles of wood, arrayed with 25 foot aisles, was burned on September 29, 1967. Other burns are planned.

Objective

The objective of the proposed research was to determine the feasibility of measuring the effects of the interactions between fallout and large fires and to design an experiment for making the measurements.

Scope

Although the experiment designed is not limited to participation in Operation Flambeau burns, its adaptability for such participation is desired.

DISCUSSION OF THE EFFECTS OF FIRE AND FALLOUT INTERACTIONS ON OCD PLANNING

Before designing an experiment to measure the interaction between mass fires and fallout deposition, the conditions under which the interaction between the two may exist should be investigated. Relationships of blast, fire, and fallout with respect to survival and escape--particularly the extent and the timing of the events, close-in to the point of detonation for single weapons of various sizes--are described by LaRiviere and Lee.[5] First, consider a single detonation. Primary and secondary ignitions occur immediately, but fire growth to coalescence may take as long as two hours. The duration of intense burning sufficient to produce a strong convection column may last more than four hours. Fallout within the potential fire environs, on the other hand, probably will arrive within the hour, and fallout cessation within this area probably will occur prior to the establishment of a mass fire or fire storm. Any interaction between fallout and fire most likely will occur after the bulk, or all, of the fallout is deposited. Any interaction between the deposited fallout and the ensuing mass fire or fire storm is of no importance to people originally located in the potential fire environs because successful escape must be completed before the interaction. If such an interaction displaces the deposited fallout downwind, however, the interaction and the resulting additional downwind fallout deposition may be important to people located downwind from the fire area.

When the problem is addressed to multiple detonations, people at a detonation location--that is, downwind from other detonations--still must attempt escape from local fires during the early minutes after the local detonation. This operation must be completed before a mass fire and its attendant convection column are established. Thus, during the period when escape is feasible, fallout from upwind detonations will not be affected locally. Fallout occurring later, when a mass fire is established and during the period of strong convection column velocities, may be displaced downwind, but once again this later interaction is not important to the people that had escaped the fire area. If such an interaction displaces the depositing fallout to downwind areas, the interaction and the resulting additional fallout deposited downwind may be important to people located downwind from the fire area.

The net effect in both the single and multiple bursts cases is the displacement of deposited or depositing fallout from an area of total destruction to areas that might otherwise be less affected by fallout.

Special conditions also can exist; for example, an air burst created fire at a location in the fallout path from an upwind surface detonation. The interaction of the thermal column with the fallout may provide a fallout free area immediately downwind from the fire, whereas, with no fire, the entire area would be blanketed with fallout.

Other special conditions are locations of refuge from fire, such as fire-free islands--for example, urban parks and building-free tracts--that are surrounded by mass fires, and areas immediately adjacent to the outside fire perimeter. In these areas, the descending fallout would be swept into the thermal updraft by the induced convective winds. The size of the areas that can be affected and the degree of the effects are not known.

If it is assumed that the convective winds and the thermal updraft created by a mass fire does, indeed, remove a large portion of the deposited and depositing fallout from the fire area, then the burned areas would constitute a relatively fallout-free area. It is unlikely, however, that such areas could be immediately and advantageously utilized because of the completeness of the destruction and the massive amounts of the residual rubble. On the other hand, debris clearance operations through the rubble, which could otherwise be calculated to be a dose-prohibiting or dose-limiting operation at early times after an attack, may, in reality, be a low-dose operation because of the fallout scouring effects created by a mass fire.

From the above discussion, it is obvious that mass fire-fallout interactions could occur. Their effects on the survivors of the attack and postattack countermeasure operations remain unsolved.

EXPERIMENTAL REQUIREMENTS

Approach

Reliable measurements of fallout and large fire interactions require a realistic simulant for the fallout particles, a large controlled fire, apparatus for dispersing the simulant on the fire area and into the fire, collectors for collecting the particles, and instruments for quantitative measurement of the collected particles.

The simulant must remain stable from the time it is dispersed until it is finally measured. It must retain its physical properties and identification through temperatures encountered in the fire, wet and dry conditions that may occur during collection, and mechanical agitation of sieving and separating. The amount present at any point must be measurable in the presence of large amounts of background material, such as fly-ash and wind-blown native soil particles.

Mineral particles of feldspar or quartz satisfactorily represent fallout particles, and radioactive isotopes are the only tracer worthy of consideration for this application. The radioisotopes are best applied directly to the mineral particles. A much less desirable alternative consists of applying a stable isotope to the mineral particle and, after the fire, producing a characteristic radioisotope by neutron irradiation of the collected particles. Compliance with all existing safety regulations is, of course, a prerequisite for experiments using radioisotopes. The unknown stability and detection efficiencies of dyes and fluorescent materials make them unacceptable for consideration as tracers at the present time.

Existing Facilities

Unique facilities for the production of synthetic fallout are located at Camp Parks, near Pleasanton, California. Multiton quantities of materials have been tagged with multicurie amounts of radioisotopes as an almost routine phase of previous OCD studies.[6,7,8] There have been reports of successful production of synthetic fallout from feldspar and quartz tagged with many different radioisotopes. Large tonnages of sized mineral particles are available from stocks at Camp Parks.

Depositing synthetic fallout at selected mass loadings on the ground in and around the combustible material prior to the fire would be almost the same operation that was successfully employed in the OCD studies mentioned above. Dispersing machines for this purpose are available at Camp Parks. Dispersing of synthetic fallout to simulate fallout particles descending into the fire has not been attempted previously. Several years ago the feasibility of synthetic fallout aerial dispersal was investigated, and an aerial disperser was designed and built. Although this machine is still available, its performance has never been evaluated, and extensive testing would be required before it could be considered a proof-tested and reliable tool for use in the field.

A special louvered tray was designed and constructed for collecting fallout particles.[9] These trays have been used extensively in many field tests, and several hundred are in storage at Camp Parks.

Special calibrated counting instruments are presently available, also at Camp Parks. For production of radioisotopes or for neutron irradiation of synthetic fallout, the General Electric Test Reactor (GETR) is nearby at Valecitos, California.

Operation Flambeau

The requirement for a mass fire would seem to be ideally filled by the controlled burns planned by Operation Flambeau. Operation Flambeau is a program of research on the behavior of mass fires conducted by the Forest Service, U.S. Department of Agriculture. Native trees are cut and piled to simulate on combustion the energy release rate of burning houses. These piles are arranged in rows and spaced with aisles to simulate the spacing of houses in a residential area. Rectangular plots of these pile layouts are built to vary from a few acres to as many as fifty acres in size. These plots are then instrumented and burned with the stated objective of measuring, describing, and understanding the behavior of mass fires.

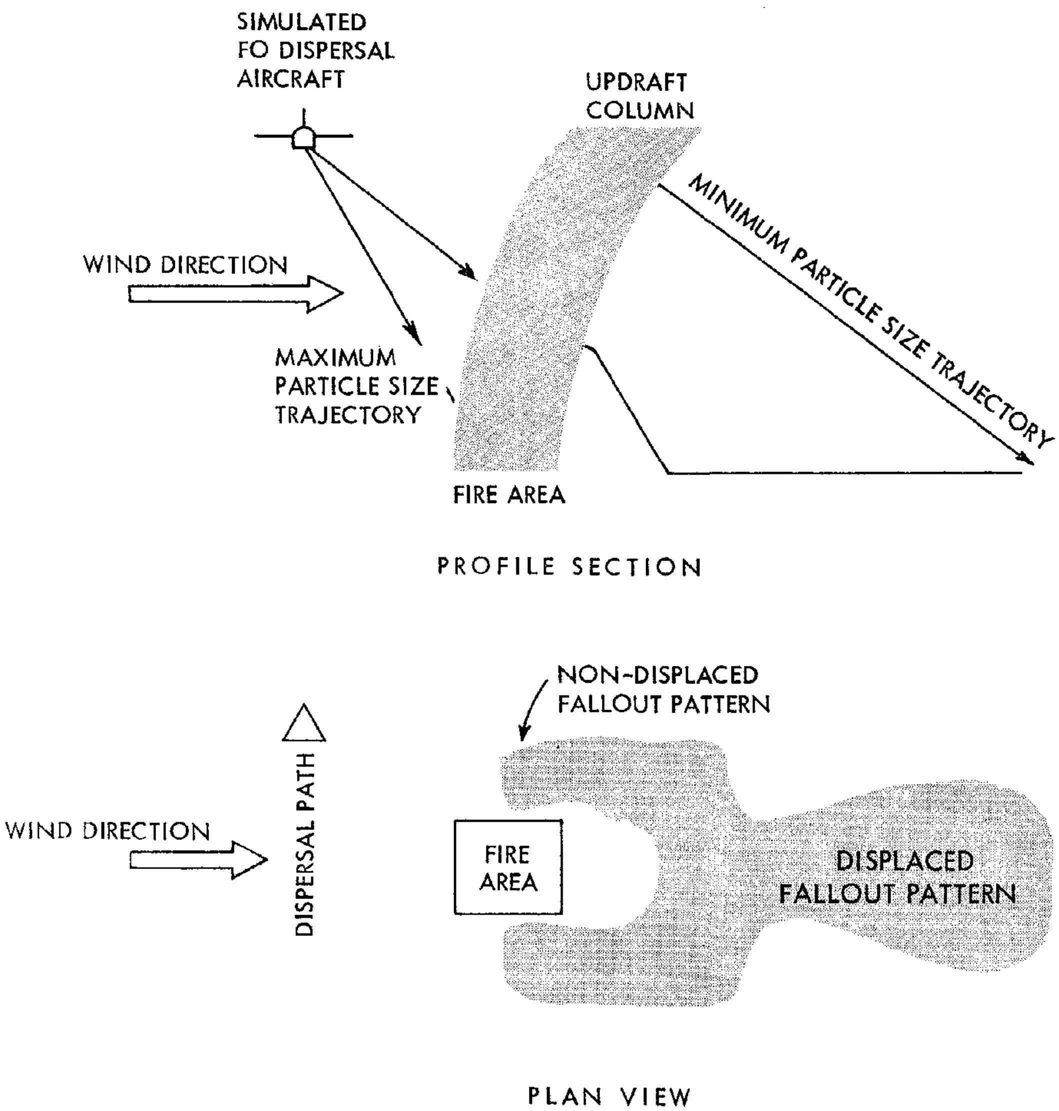
Experimental Plan

Situation I: Fire going on when fallout arrives.

If a swath of synthetic fallout were dispersed in the air over the fire, as shown in Figure 1, and if the swath extended out on both sides of the fire to a distance that would ensure normal settling of falling particles, then any change in the fallout pattern caused by the fire could be measured.

FIGURE 1

SITUATION I EXPERIMENTAL PLAN



Situation II: Fallout on ground before fire builds up.

A test of the redistribution of fallout in a contaminated area would not require aerial dispersion of the particles. Synthetic fallout deposits of known mass loading would be placed on the ground over specific areas at selected locations within the plot prior to the fire.

The two experiments, aerial dispersing and redistribution, could be conducted at the same burn by tracing with two radioisotopes that could be distinguished from each other by differences in half-life or radiant emissions.

Theoretical Calculations

Fallout particles should be dispersed in amounts sufficient to cover the burn area and downwind environs with detectable deposits. However, the concentration must be sufficiently low to ensure that the particles would fall at their own terminal velocity. The amount required per linear cross-wind distance can be estimated by determining the heights of origin and the fall trajectories of various size particles for various wind speeds.

If particles of various sizes are injected into a thermal column, particle size fractionation within the column will occur. The smaller particles will be displaced vertically to a greater height than will the larger particles. As a consequence, on leaving the thermal column, the maximum elevation of the smaller particles will be greater than that of the larger particles.

The height of the fire convection column of the Operation Flambeau Test Fire 760-12-67 was estimated to be 10,000 feet. Maximum vertical velocities (μ_{max}) in the thermal column were estimated to range from 50 feet per second to 300 feet per second. If the maximum vertical velocity is assumed to occur at a height equal to the fire diameter,* then the vertical velocity in the column decelerates from the maximum to zero between the altitudes of 1,500 ft and 10,000 ft. If it is further assumed that the deceleration is described by the classical equation,

$$S = 1/2\ at^2,$$

then the column velocities at various heights are indicated in Figure 2 for maximum velocity values of 50, 100, and 300 feet per second.

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* Private communication with Mr. W. J. Parker from USNRDL.

Terminal falling velocities of particles with micron diameters of 44, 88, 175, 350, and 500 are also indicated in Figure 2. Altitudes from which particles of the indicated sizes would begin their descent are indicated by the intercepts with the curves of thermal column velocities. The downwind distance of particle deposition depends on wind velocities from maximum altitude to ground level, the time of ascent, and the time of descent. If the wind velocity is assumed constant at all altitudes, then the downwind distances of deposition for the four particle size ranges are as listed in Table 1 for wind velocities of 3, 5, 7, and 10 miles per hour.

The calculations of the altitudes reached by the various particle sizes were based on uniformly decelerating column velocities from estimated maximum column velocities. These hypothetical conditions will be influenced by many forces in the real situation. As noted later, many independent fire swirls were observed during the period of intense burning, and colored smoke indicators introduced in and over the fire zone at various altitudes indicated the presence of downdrafts, as well as horizontal in-drafts. Thus, the thermal column is more aptly described as a turbulent swirling mass of gases and particles moving in all directions, but with a net ascending vertical vector. There are at present insufficient data to describe this fire behavior in mathematical terms with enough precision to predict the displacement of a fallout particle which interacts with these turbulent swirling gases.

A knowledge of particle size, density, point of origin, and location of deposition may permit a description of the particle trajectories, which, in turn, may be useful in determining convection column velocities that thus far have not been measured satisfactorily.

FIGURE 2

THERMAL COLUMN VELOCITIES

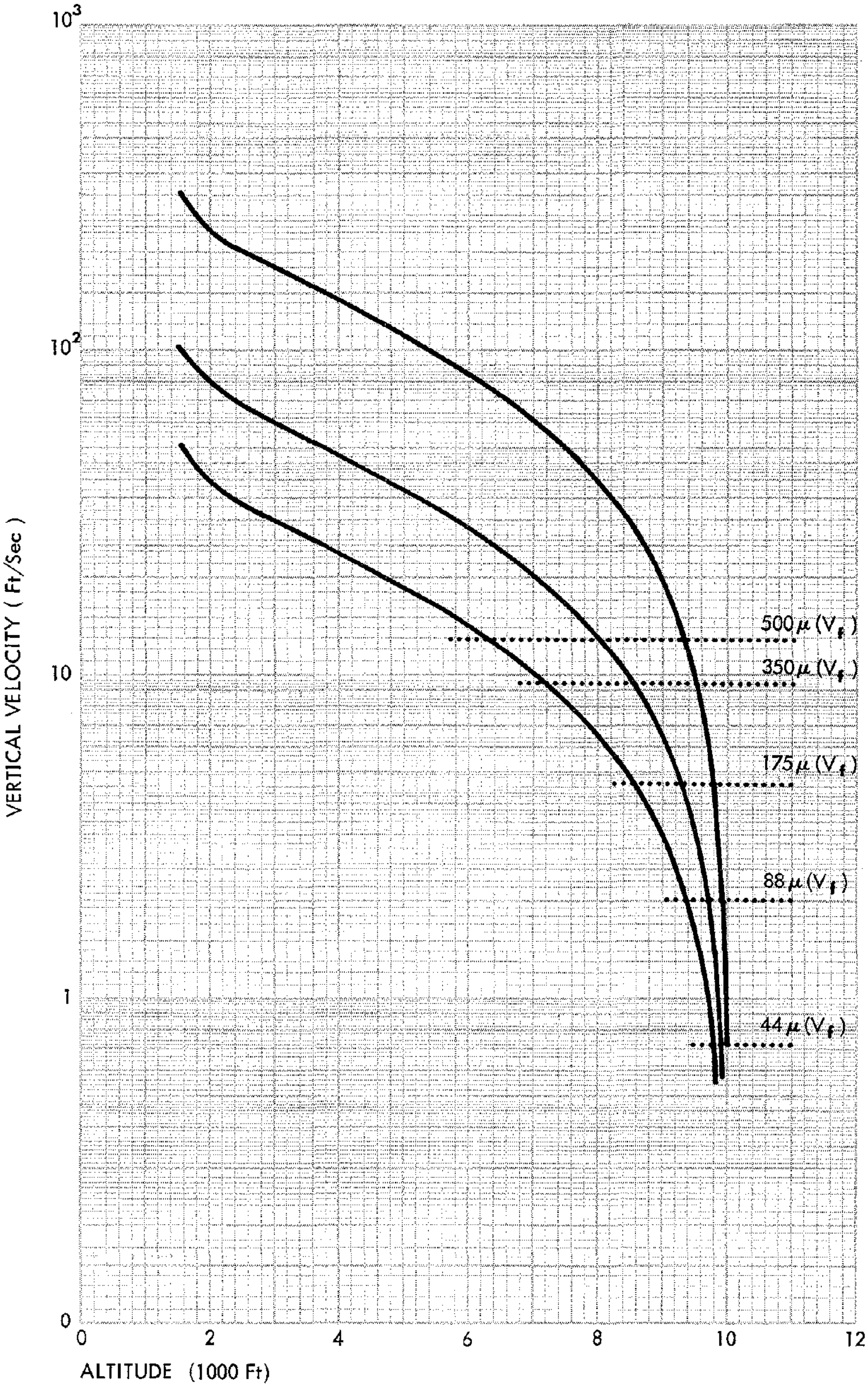


Table 1

DOWNWIND DEPOSITION DISTANCE
(Miles)

(μ_{max}) (ft/sec)	Particle Size (micron)	V_w (mph) 3	5	7	10
50	350-500	0.62-0.80	1.02-1.34	1.43-1.86	2.05-2.67
50	175-350	0.80-1.84	1.34-3.07	1.86-4.30	2.67-6.14
50	88-175	1.84-4.27	3.07-7.11	4.30-9.96	6.14-14.2
50	44- 88	4.27-11.8	7.11-19.6	9.96-27.5	14.2-39.3
50	44-500	0.62-11.8	1.02-19.6	1.43-27.5	2.05-39.3
100	350-500	0.65-0.91	1.09-1.52	1.53-2.12	2.18-3.02
100	175-350	0.91-1.84	1.52-3.08	2.12-4.31	3.02-6.16
100	88-175	1.84-4.25	3.08-7.09	4.31-9.93	6.16-14.1
100	44- 88	4.25-11.8	7.09-19.7	9.93-27.5	14.1-39.3
100	44-500	0.65-11.8	1.02-19.7	1.53-27.5	2.18-39.3
300	350-500	0.66-0.90	1.10-1.51	1.53-2.11	2.19-3.03
300	175-350	0.90-1.83	1.51-3.06	2.11-4.29	3.03-6.12
300	88-175	1.83-4.24	3.06-7.07	4.29-9.90	6.12-14.2
300	44- 88	4.24-11.8	7.07-19.6	9.90-27.4	14.2-39.3
300	44-500	0.65-11.8	1.10-19.6	1.53-27.4	2.19-39.3

OUTLINE OF AN EXPERIMENT

This test consists of tracing three discrete mineral particles of different size that are allowed to settle over and into a large controlled burn (see Figure 1). Wedron sand, a quartz mineral, has the required physical characteristics. Particle size ranges of 44-88, 175-350, and 500-1000 microns would simulate important fallout, and a gross collection containing them can be readily sieved and the fractions measured separately.

If an acceptable wind speed and direction for the burn can be dictated by this project (to ensure compliance with all radiological safety regulations), a low energy gamma emitting radionuclide would be used for the tracer. Lu-177 is an isotope of choice. It can be produced readily by neutron irradiation, and its 6.8 day half-life is sufficiently long to make experimental measurements, yet is short enough to decay to non-detectable levels in two months. The 0.2 mev gamma ray of Lu-177 can be measured by scintillation counting, yet is soft enough to be attenuated by practical shielding thicknesses.

At Camp Parks, 100 pounds of each of the three particle sizes would be tagged with 1 curie of Lu-177, and the sizes then thoroughly blended together. The 300 pounds would be packaged and shipped to Montgomery Pass, Nevada (for Operation Flambeau participation).

A private landing strip is located about three miles from the Operation Flambeau burn area, and permission to use the strip was readily obtained in conversations with the local rancher. A 500 pound capacity crop dusting plane would be fitted with 200 pounds of shielding and loaded with the 300 pounds of synthetic fallout.

The 300 pounds of synthetic fallout would be dispersed in a single swath 50 feet wide and 3,000 feet long, extending through the fire zone and for 1,000 feet on each side. The maximum deposit on the ground would be less than 1 gm/ft^2.

The radiation dose rate would not exceed 0.1 mr/hr at a height of three ft in the center of the swath. This is about equivalent to natural background radiation, and is below the level of 0.5 mr/hr that currently defines a contaminated area.

With an acceptable wind speed of five miles per hour and assuming that the particles in a crosswind length of 2,000 ft are drawn into the convection column, a downwind deposition pattern can be characterized for a 1,000 foot wide path. With these conditions the values in Table 2 were computed for the selected particle sizes of synthetic fallout.

Table 2

FALLOUT DEPOSITION

Size	Deposition Location		Synthetic Fallout	
	Distance	Area	Density	Activity
(micron)	(miles)	(ft^2)	(mg/ft^2)	($d/s/ft^2$)
44-88	6.5-19	6.5×10^7	0.47	95
175-350	1.2-2.8	8.1×10^6	3.7	760
500-1000	0.40-0.83	2.3×10^6	13	2700

The depositing particles would be collected in louvered trays, close-in, and on plastic sheets at greater distances from the fire. The collected particles would be recovered as soon as possible after the fire and returned to Camp Parks for processing and measurements. The contents of each collector would be sieved and the sized fractions measured in a well-crystal scintillation counter. After decaying through two half-lives, the remaining Lu-177 activity would still quantitatively trace one milligram of synthetic fallout.

The redistribution of fallout in a previously contaminated area could be measured with another batch of synthetic fallout at another one of the three test fires. A double batch of synthetic fallout (600 pounds) could be readily produced, and since most of the hardware would be at the test site, the cost of conducting the second experiment would be minimal. The use of a second radioisotope, as previously mentioned, would enable the two measurements to be conducted simultaneously; however, the costs of preparing different synthetic fallout batches and the additional costs for the more complex radiochemical analyses could not be justified unless Project Flambeau were conducting only a single burn.

The inclusion of additional detecting equipment, i.e. an array of strategically placed Time of Arrival Detectors (TOADS) would provide data on fallout movement with respect to time.

PRELIMINARY EXPERIMENTAL PARTICIPATION IN OPERATION FLAMBEAU

During the present study a scheduled Operation Flambeau burn permitted an opportunity for project personnel to generally observe the phenomenon and to participate on a very limited scale.

Experimental Test Fire 760-12

The fire plot was at an elevation of 7,500 feet in the U.S. Forest Service Montgomery Pass, Nevada test site. This remote area is located about 70 miles north of Bishop, California and 200 miles south of Reno, Nevada. A 50-acre area was covered with 342 piles of well-dried native trees. Each pile was about 50 feet on a side, 6 feet high, and contained some twenty tons of fuel. The piles were arranged in rows with 25-foot aisles, and the rectangular plot had 18 rows in one direction and 19 in the other, as shown in Figure 3.

Experiments for Wind Statistics Program

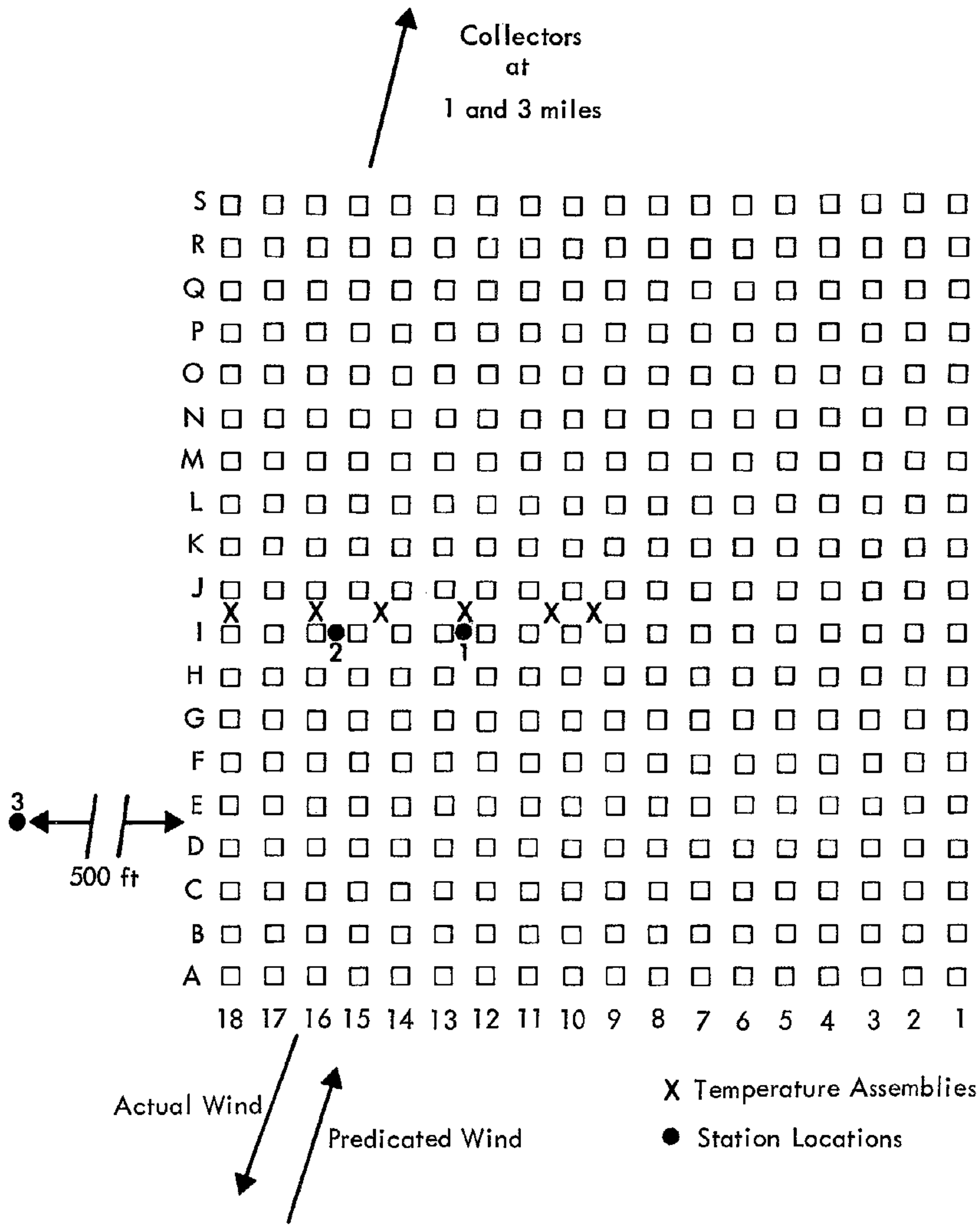
Participation in the controlled burn yielded some valuable information, although no detailed quantitative experiments were planned. A simple experiment was integrated into the test plan and conducted with the help and cooperation of Operation Flambeau personnel.

This experiment furnished information that was directly pertinent to the determination of whether an experiment on fire-fallout interactions was feasible. The information consisted of three parts as follows. First, it was demonstrated that there was, in fact, an interaction between mass fires and fallout particles. Second, it was determined that the louvered trays for collecting fallout particles could be used in the fire zone. Third, measurements of the surface temperatures in the aisles were obtained; (apparently these temperatures had not been measured previously, and they were necessary for the selection of the collector construction material).

Mineral quartz was sieved, and 10 pounds of particles were collected in each of the following micron diameter size ranges: 44-88, 88-175, 175-350, and 350-500. Particles of this size are important in real fallout.[10] Each of the size fractions was tagged with 1 milligram per gram of stable lanthanum-139, so that lanthanum-140 could be produced

FIGURE 3

PLOT OF FLAMBEAU FIRE 760-12



by neutron irradiation to positively identify the redistributed particles that were collected during the course of the fire.

At two locations (stations 1 and 2 on Figure 3), four steel plates were secured to the ground a little below ground level. Five pounds of particles of each of the four size fractions were spread over a plate so that a rather normal surface resulted, as is shown in Figure 4.

An aluminum tray collector was exposed at station 2, and large stones were used to secure the louvered inserts in place, as shown in Figure 4. A one-hundred gram aliquot of tagged particles from each size fraction was added to the tray. Four other collectors were exposed at 0.3 mile intervals on an arc that was estimated to be one mile from the fire in the predicted downwind direction. Four plastic sheets, each 4 feet on a side, were coated with petroleum jelly and exposed on a similar arc at an estimated three miles downwind (see Figure 5).

Surface temperatures were measured with Tempil Pills. These tablets are compounded so that they melt at specified temperatures. Each tablet is stamped with its melting temperature and is further identified by a characteristic color. Stainless steel counting planchets, each containing three tablets, were stacked one atop the other and held together by a through-bolt, and each such assembly held tablets to measure temperatures from 100°F to 2100°F at 100°F intervals. One of these assemblies was placed on the ground in the center of the aisle at six locations from near the center to the edge of the fire zone, as noted in Figure 3.

Observations During the Burn

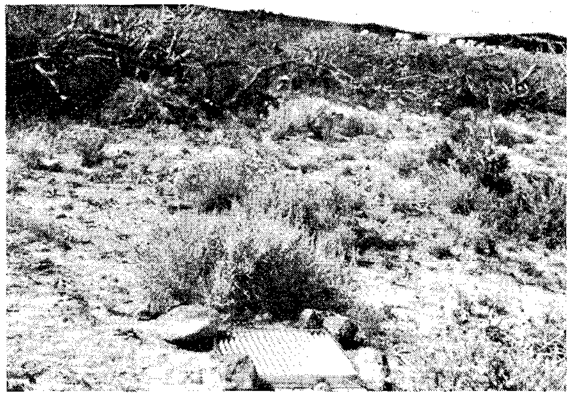
Observations were made 500 feet from the edge of the burn at station 3 in Figure 3.

The plot was ignited at 7:57 a.m. PDT on September 29, 1967. Unfavorable weather forced several postponements, and since another heavy rain was forecast for September 30, a decision was made to accept the less than ideal weather conditions. The weather condition that affected the particle movement study most was wind direction. Plans called for a NE wind and the prevailing wind during the burn was SW. This condition denied the possibility of collection and identification of the synthetic fallout particles that otherwise may have been collected in the trays that were placed SW from the fire.

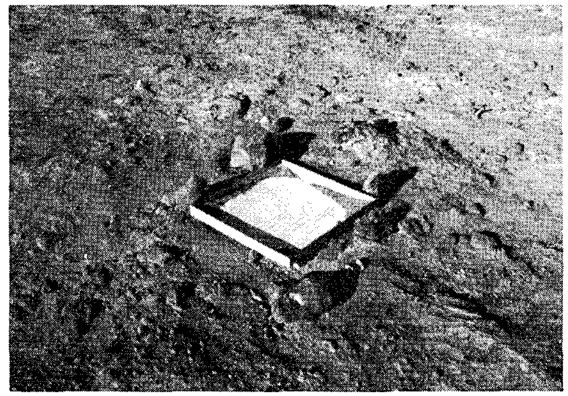
Ignition seemed near perfect as smoke and fire appeared on all piles. The fire developed rapidly, producing thick black smoke that soon formed a convection column and a cloud that drifted over the northeast corner of the plot. A strong in-draft wind was noticed at station

FIGURE 4

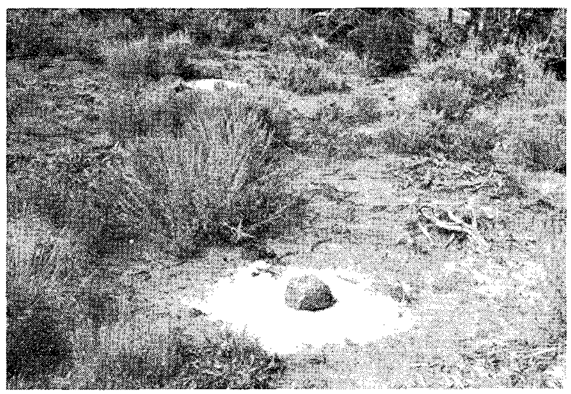
MOVEMENT OF PARTICLES BY FIRE-STORM



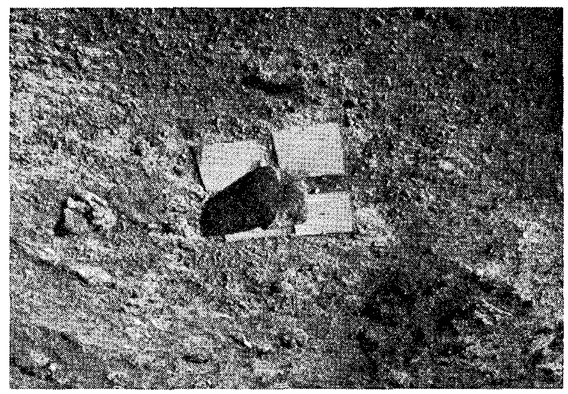
Tray collector in place before fire



Tray collector after fire



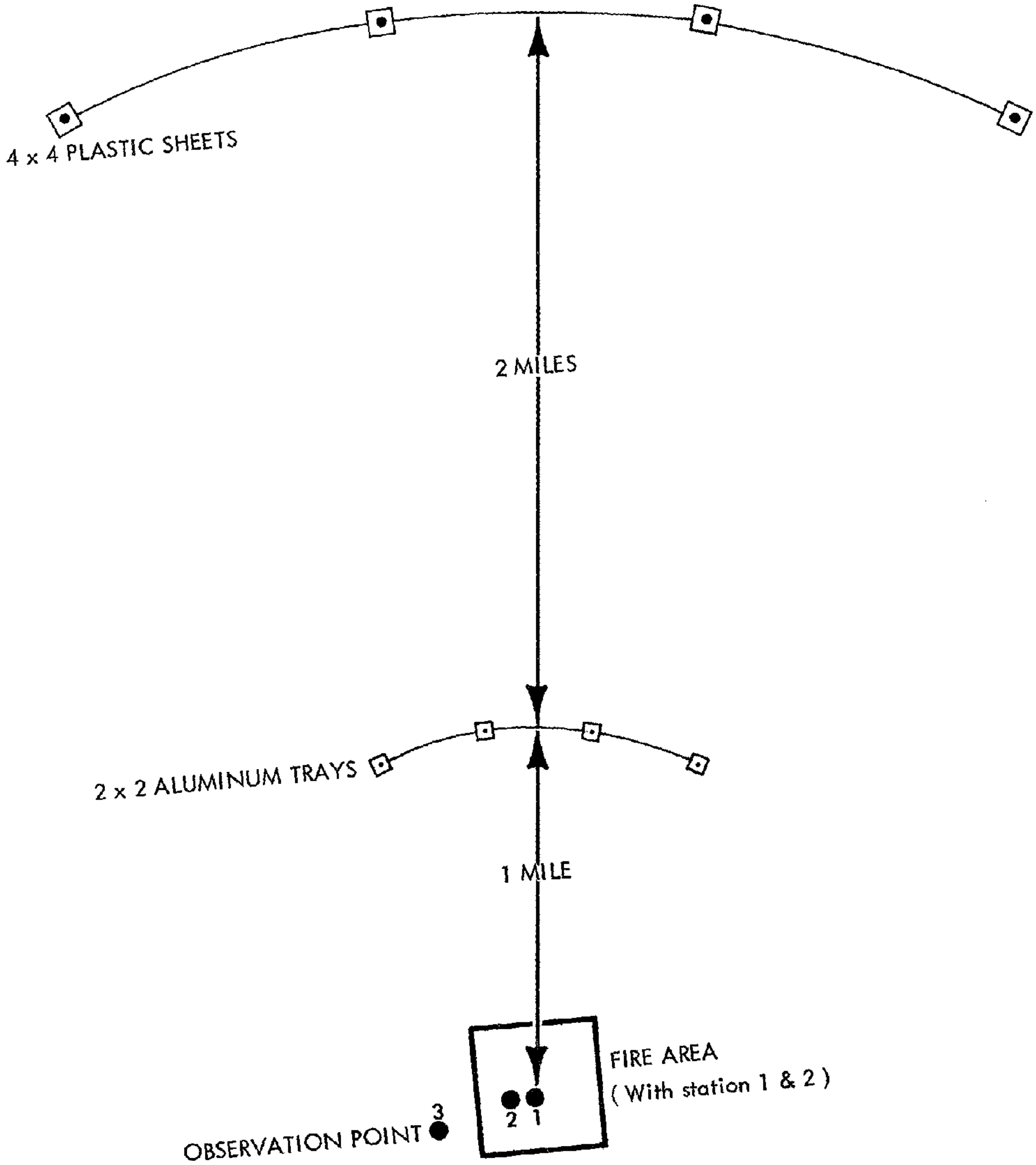
Twenty pounds of tagged particles covering steel plates



Steel plates after fire

FIGURE 5

COLLECTOR ARRAY



3 within the first 3 minutes. Fire action seemed to peak in the first 5 minutes, and at 6 minutes the smoke was turning from black to grey. At 10 minutes, the rows of piles were again visible almost to the center of the plot.

Fire swirls that were visible from the observation station were spectacular. Most action appeared to be in the NE quarter of the plot. The swirls rotated counterclockwise on the north side of the plot, and clockwise on the east side. Some swirls appeared to be heavily loaded with dirt, while others carried large pieces of burning wood to heights of perhaps 100 feet before they fell back into the fire, or, in a few cases, out of the fire area. It was not possible to determine the disposition of the dirt in the swirl by visual observation. Large swirls were preceded by the sound of a howling wind, and the noise level became a muffled roar as the swirls appeared and increased in intensity.

The convection column was surprisingly narrow, and it appeared to tilt toward the observation station. The black cloud passed directly overhead and seemed to enlarge very little by diffusion as it drifted downwind. The black color of the drifting cloud suddenly disappeared and was replaced with what appeared to be a characteristic water condensation plume at about eight minutes.

As the cloud passed overhead, several qualitative tests failed to detect falling mineral particles. Extensive experience in Costa Rica[11] showed that small falling particles that were generated by the eruptions of Vulcan Irazu could be detected by feeling them on the nose or between the teeth long before they were visible. An even more sensitive test for falling particles consisted of noting the irregular flow of ink from a ballpoint pen as field notes were entered on white paper. No particles were detected by any of these tests during the course of the burn.

Smoke signals generated upwind at the edge of and above the fire zone indicated that downdrafts occur quite near the ascending convection column. Such downdrafts would, of course, have a significant effect on fallout deposition patterns.

Most of the burning was reduced to small independent fires after one hour. At this time, a search was conducted for evidence of falling particles. The path covered by the drifting cloud was comparatively easy to follow by noting fly ash on vegetation and on large flat rocks. This trail dimmed about one mile downwind and could no longer be followed after some two miles. No evidence of freshly deposited mineral particles was found, although at previous fires mineral particles were observed on new snow some two miles downwind.*

Observation of large aircraft and helicopters operating in the airspace over the burn indicated that thermal effects would not be a problem in synthetic fallout aerial dispersal operations.

Experimental Results

The burned-out plot was easily entered the following morning, with little discomfort from smoke, although a few small fires were still burning.

Five of the six temperature measurement assemblies were recovered. Some had been moved as much as ten feet, but others were found exactly where they were placed the previous day. The sixth assembly, which was nearest the edge of the plot, was not found, even though an extensive search was conducted over an area about 100 feet in radius. When the assemblies were dismantled, it was found that at all five locations the pills up to and including the 700°F one had melted, while none of the 800°F pills showed evidence of fusing. Aluminum tray collectors would thus be satisfactory for surface sampling, even in the center of the fire area.

The tagged sand at station 1 was undisturbed, and water drops were found on the bottom side of the steel plates when they were removed from under the sand piles.

The effects at station 2 were quite different. All of the tagged sand had been removed from the steel plates, as shown in Figure 4. The comparatively clean condition of the plates after the fire indicates that no redeposition occurred on these smooth surfaces, or that if redeposition did occur, it was subsequently removed. The condition of the tray collector at station 2 is best evidenced by the pictures in Figure 4. The large rocks were rolled back when the louvered inserts were forcibly removed from the tray. No trace of the louvers or spacer bars was found in an extensive search of the area. All of the tagged particles (100 gm aliquots of each size) were removed from the collector tray, and in their place were the much larger native type particles seen in Figure 4. Many of these native type particles were ten mm in diameter. Their unusual location in the four corners of the tray indicates that they were subjected to circular wind motions.

* Private communication with Mr. Clive Countryman, Pacific Southwest Forest and Range Experiment Station, Riverside, California.

It is evident from the before and after pictures in Figure 4 that all vegetation was destroyed and much of the loose surface soil in the vicinity of station 2 was blown away.

CONCLUSIONS

1. Assessments of postattack casualties and the constraints on some postattack emergency operations could be significantly altered if the deposition of fallout is significantly affected by the presence of mass fires or fire storms.

2. Interactions were observed between synthetic fallout particles and a large fire. Mineral particles from 44 to 500 microns in diameter were carried away by fire storm winds. The location of their redeposition is not known.

3. An experiment to measure the interactions between fire and fallout is feasible. Much of the technology has been developed previously and used in successful studies for the Office of Civil Defense. The hardware from these studies has been retained and stored at Camp Parks. A very significant fraction of the total hardware required for the proposed experiment is available from these stores.

4. Observation of Flambeau Test Fire 760-12 revealed no major shortcomings in the experimental design presented herein, although many options exist in the selection of radioisotope, particle size, and method of dispersal.

RECOMMENDATIONS

1. It is recommended that the interactions between fire and fallout be measured at one of the three test fires scheduled by Operation Flambeau for summer 1968.

2. It is recommended that an analytical model describing the interaction between fire and fallout be formulated.

3. It is recommended that the consequences of the interaction between fire and fallout be analyzed with respect to postattack operations.

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